

AD-A104 708 ARMY ENGINEER DISTRICT ST LOUIS MO
NATIONAL DAM SAFETY PROGRAM. BUTTERFLY LAKE DAM (MO 30501) AND --ETC(U)
SEP 78 A L JOHNSON

F/6 13/13

NL

UNCLASSIFIED

For I
ADA
G3-706

END
DATE
FILED
10-81
DTIC



AD A104708

DISCLOSURE STATEMENT A

Approved for public release;
Distribution unlimited

REF ID: A6570
SEP 29 1981

A

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
	AD-A104	708
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Rainbow Lake Dam (MO 30641) Ste. Genevieve County, Missouri	5. TYPE OF REPORT & PERIOD COVERED Final Report	
7. AUTHOR(s) Corps of Engineers, St. Louis District	6. PERFORMING ORG. REPORT NUMBER	
	8. CONTRACT OR GRANT NUMBER(s) N/A	
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 11.1	
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	12. REPORT DATE September 1978	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) National Dam Safety Program. Butterfly Lake Dam (MO 30501) and Rainbow Lake Dam (MO 30641), Mississippi - Kaskaskia - St. Louis Basin, Ste. Genevieve County, Missouri. Phase I Inspection Report.	13. NUMBER OF PAGES Approximately 45	
16. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) Approved for release; distribution unlimited.	15. SECURITY CLASS. (of this report) UNCLASSIFIED	
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Butterfly Lake Dam (MO 30501) Ste. Genevieve County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report
7. AUTHOR(s) Corps of Engineers, St. Louis District		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		8. CONTRACT OR GRANT NUMBER(s) N/A
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		12. REPORT DATE September 1978
		13. NUMBER OF PAGES Approximately 45
16. DISTRIBUTION STATEMENT (of this Report) Approved for release; distribution unlimited.		15. SECURITY CLASS. (of this report) UNCLASSIFIED
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

RIVER AUX VASES BASIN

BUTTERFLY AND RAINBOW LAKES
STE. GENEVIEVE COUNTY, MISSOURI

MISSOURI INVENTORY NOS.
BUTTERFLY LAKE MO. 30501
RAINBOW LAKE MO. 30641

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY: ST. LOUIS DISTRICT CORPS OF ENGINEERS
FOR: GOVERNOR OF MISSOURI

SEPTEMBER 1978

Attachment F

Key date: 1473
AF

A

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Butterfly and Rainbow Lakes
State Located	Missouri
County Located	Ste. Genevieve
Stream	River aux Vases
Date of Inspection	21 August 1978

Butterfly Lake Dam No. Mo. 30501 and Rainbow Lake Dam No. Mo. 30641 were inspected using the "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed by the Chief of Engineers, U. S. Army, Washington, D. C., with the help of Federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines are considered to represent a consensus of the engineering profession.

Based on the criteria in the guidelines, the dams are in the high hazard potential classification, which means that loss of life and appreciable property loss could occur in the event of failure of the dams. Four houses would be subjected to flooding with possible damage and/or destruction and possible loss of life. Butterfly Dam is in the intermediate size classification since it is greater than 40 feet high. Rainbow Dam is in the small size classification because it is greater than 25 feet high.

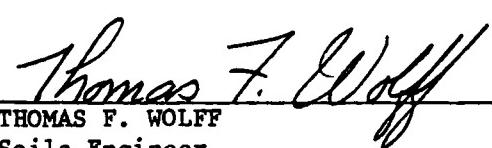
Inspection and evaluation indicate that the outlet facilities of Butterfly and Rainbow Lakes do not meet the criteria set forth in the guidelines for dams having the above size and hazard potential. Butterfly Dam is an intermediate size dam with a high hazard potential required by the guidelines to pass the PMF. It was determined that the outlet facilities will pass 20 percent of the PMF without overtopping the dam. Rainbow Dam is a small size dam with a high hazard potential required by the guidelines to pass from one-half PMF to the PMF. However, considering the high hazard potential to life (four families) and property downstream of the dam, the outlet facilities should be able to pass the PMF without overtopping the dam. It was determined that the outlet facilities will pass 15 percent of the PMF without overtopping the dam.

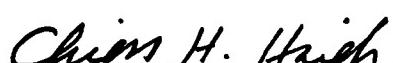
The outlet facilities of Butterfly Dam will pass the 100-year flood without overtopping the dam. Rainbow Dam outlet facilities will not pass the 100-year flood. The 100-year flood is defined as a flood that has a 1 percent chance of being equalled or exceeded during any given year.

Since the outlet facilities for the Butterfly Lake and Rainbow Lake Dams are not capable of passing a minimum of one-half (50 percent) of the PMF without overtopping the dam and causing failure, the outlet facilities are considered seriously inadequate and the dams are accordingly classified unsafe, non-emergency structures.

Other deficiencies visually observed by the inspection team were need for removal of brush and small trees on the dam and spillway, and the need for riprap protection at the dam/spillway interface to prevent erosion from high spillway flows. The lack of stability and seepage analyses on record is a deficiency that should be corrected.

It is recommended that the owner take action to correct or control the deficiencies described.


THOMAS F. WOLFF
Soils Engineer
St. Louis District
Corps of Engineers

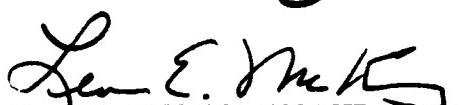

CHIEN H. HSIEH
Hydraulic Engineer
St. Louis District
Corps of Engineers

SUBMITTED BY:

 for Chief, Engineering Division

20 Sep 78
Date

APPROVED BY:

 Colonel, CE, District Engineer

20 Sep 78
Date



Overview of Butterfly Lake, Rainbow
Lake and Kal-Tatri Lake

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BUTTERFLY LAKE DAM - ID NO. 30501
RAINBOW LAKE DAM - ID NO. 30641

TABLE OF CONTENTS

<u>Paragraph No.</u>	<u>Title</u>	<u>Page No.</u>
SECTION 1 - PROJECT INFORMATION		
1.1	General	1
1.2	Description of Project	1
1.3	Pertinent Data	2
SECTION 2 - ENGINEERING DATA		
2.1	Design	6
2.2	Construction	5
2.3	Operation	6
2.4	Evaluation	6
SECTION 3 - VISUAL INSPECTION		
3.1	Findings	7
3.2	Evaluation	9
SECTION 4 - OPERATIONAL PROCEDURES		
4.1	Procedures	10
4.2	Maintenance of Dam	10
4.3	Maintenance of Operating Facilities	10
4.4	Description of Any Warning System in Effect	10
4.5	Evaluation	10
SECTION 5 - HYDRAULIC/HYDROLOGIC		
5.1	Evaluation of Features	11
SECTION 6 - STRUCTURAL STABILITY		
6.1	Evaluation of Structural Stability	13
SECTION 7 - ASSESSMENT/REMEDIAL MEASURES		
7.1	Dam Assessment	14
7.2	Remedial Measures	14

LIST OF PLATES

1. Location Map
2. Profile (Butterfly Lake)
3. Cross Section (Butterfly Lake)
4. Profile and Cross Section (Rainbow Lake)

APPENDIX

- A. Hydrologic and Hydraulic Analysis Computations
- B. Design Data From 1973 Repairs to Butterfly Lake

LIST OF PHOTOGRAPHS

<u>Photo No.</u>	<u>Title</u>
1	Butterfly Dam
2	Butterfly Dam - Downstream Slope
3	Butterfly Dam - Upstream Slope
4	Butterfly Dam - Piezometers
5	Butterfly Dam - Seep in Right Abutment
6	Butterfly Dam - Drainage System Outlet
7	Butterfly Dam - Outlet Channel
8	Butterfly Dam - Outlet
9	Butterfly Dam - Emergency Spillway
10	Butterfly Dam - D.S. Side, Emergency Spillway
11	Rainbow Lake
12	Rainbow Dam - Emergency Spillway in Foreground
13	Rainbow Dam - Downstream Slope
14	Rainbow Dam - Downstream Slope
15	Rainbow Dam - Upstream Slope
16	Rainbow Dam - Upstream side of Outlet
17	Rainbow Dam - Downstream Side of Outlet
18	Rainbow Dam - Spillway and Outlet Channel

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BUTTERFLY LAKE DAM - ID NO. 30501
RAINBOW LAKE DAM - ID NO. 30641

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of the Butterfly Lake Dam and Rainbow Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. Butterfly and Rainbow Lakes are earth dams which provide recreational lakes for a girl scout camp. Butterfly Lake is the upstream-most of a series of three lakes; Rainbow Lake is in the middle. A third lake, Lake Kal-Tatri, immediately downstream of Rainbow, has a separate owner and was not part of this inspection. Butterfly Lake has a spillway consisting of six 24-inch corrugated metal pipes with concrete headwalls at the left abutment and an auxiliary spillway under construction along a westward extension of the dam axis. Rainbow Lake has a spillway consisting of four 50-inch x 31-inch corrugated metal pipe arches with concrete headwalls at the right abutment.

b. Location. Section 27 and 34, Township 36 North, Range 7 East.

c. Size Classification. Intermediate for Butterfly Lake Dam and small for Rainbow Lake Dam.

d. Hazard Classification. High.

e. Ownership. River Bluffs Girl Scout Council, Glen Carbon, Illinois.

NOTE: The property line reportedly passes through Rainbow Dam, placing the downstream slope on the property of Mr. Kalicak, owner of the other lake downstream.

f. Purpose of Dam. Recreation - Resort Area.

g. Design and Construction History. The dams were built in the mid-1960's (Butterfly, 1962; Rainbow, 1964) by Mr. Kalicak, a contractor and owner of the downstream lake (Kal-Tatri MO. 31039). The dams were acquired by the Girl Scouts in approximately 1967. No preconstruction design information or detailed construction data is known to exist. However, significant remedial work was done to Butterfly Lake in 1973 by Ballman Construction Company. M. B. Corlew & Associates, Edwardsville, Illinois, performed the design and engineering support for the repairs. Repairs included restoration of an eroded area, installation of drains, filling of cracks, spillway repairs, and installation of pore pressure and movement instrumentation. See Appendix B to this report for a drawing of these repairs. Accompanying engineering reports are on record.

h. Normal Operating Procedure. No operating records exist. At both (2) dams, outflow passes through ungated culverts.

1.3 PERTINENT DATA

a. Combined Drainage and Lake Surface Area.

1.83 square miles (Butterfly)
0.89 square miles (between Butterfly and Rainbow)
2.72 square miles (upstream of Rainbow)

b. Discharge at Damsite.

(1) Estimated ungated emergency spillway capacity at maximum pool elevation.

1770 cfs (Butterfly)
1180 cfs (Rainbow)

(2) Estimated culvert spillway capacity at maximum pool elevation.

205 cfs (Butterfly)
405 cfs (Rainbow)

(3) Estimated experienced maximum flood at damsite - Unknown.

c. Elevation (Feet Above M.S.L.). (Reference to benchmark used by consulting engineer; 802.0 flow line of second culvert at Butterfly Dam.)

(1) Top of dam (minimum elevation of earth embankment).

808.0 (Butterfly)
771.4 (Rainbow)

(2) Spillway crest.

803.5 (Butterfly)
767.7 (Rainbow)

(3) Upstream Outlet Invert.

802.15 (Butterfly)
765.56 (Rainbow)

(4) Downstream Outlet Invert.

801.71 (Butterfly)
765.26 (Rainbow)

(5) Maximum tailwater - Unknown.

(6) Streambed at centerline of dam - estimated.

740 (Butterfly)
735 (Rainbow)

d. Reservoir. Length of maximum pool.

5200 feet (Butterfly)
1200 feet (Rainbow)

e. Storage (Acre-feet). Top of Dam Estimated.

1030 (Butterfly)
460 (Rainbow)

f. Reservoir Surface (Acres).

(1) Top of dam.

75 acres (Butterfly)
45 acres (Rainbow)

(2) Spillway crest.

65 acres (Butterfly)
35 acres (Rainbow)

g. Dam.

(1) Butterfly Dam.

Type - Earthfill.

Length - 1100 feet.

Height - 41 \pm feet above Rainbow Lake water surface.

Top width - 22 feet.

Side Slopes - 1 V on 3 H.

Zoning - Unknown.

Impervious Core - Unknown.

Cutoff - Unknown; concrete wall 5 feet high by 8 inches wide for entire length of dam, per Mr. Kalicak, original owner and builder.

Grout curtain - Unknown.

(2) Rainbow Dam.

Type - Earthfill

Length - 900 feet

Height - 30.5 \pm feet

Top width - 16 feet.

Side Slopes - 1 V on 2.5 H.

Zoning - Unknown.

Impervious Core - Unknown.

Cutoff - Unknown; none according to Mr. Kalicak, original owner and builder.

Grout curtain - Unknown.

h. Outlet Works.

Types.

6-24-inch cmp (Butterfly)
4-50- x 31-inch cmp (Rainbow)

i. Emergency Spillway. See Section 5, paragraphs 5.1c(3) and 5.1c(4) for a description of each spillway.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design drawings or data are known to exist for the original construction of Butterfly Dam or Rainbow Dam. However, major repairs to Butterfly Dam were designed by M. B. Corlew & Associates in 1973 after a stability analysis of the then-existing conditions in a slide area. Pertinent design data are included in Appendix B. No detailed stability analyses or seepage analyses of the existing dam are on record.

2.2 CONSTRUCTION

The two dams were reportedly constructed by the previous owner, Mr. Kalicak, a contractor. No detailed information was found to be available. However, Mr. Kalicak, the original owner and builder, stated that the dams were constructed using borrow material from the lake area, placed in less than 12-inch lifts and compacted with sheep'sfoot roller. The dams are founded on rock. Mr. Kalicak stated that Butterfly Lake has a 5-foot high by 8-inch wide concrete cutoff wall the entire length of the dam.

2.3 OPERATION

The Girl Scout Council maintains a file of pertinent information regarding repair, major maintenance, engineer's reports, etc. The owner has periodically engaged the engineer to read piezometers and evaluate the dam.

2.4 EVALUATION

a. Availability. Pertinent information is maintained by the owner and the engineer and was made available to the inspection team.

b. Adequacy. The background data and analyses furnished by the owner and engineer and the field surveys and visual inspections presented herein are considered adequate to support the conclusions of this report. Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be rectified.

c. Validity. The design of repairs to the Butterfly Dam is considered to have been performed in accordance with good engineering practice.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. Four representatives of the Girl Scout Council accompanied the inspection team. The downstream slope of Rainbow Lake was reported to be off the Girl Scout property, but was inspected by the team. A third, smaller lake, is located immediately downstream but is owned by Mr. Kalicak, the previous owner of the Girl Scout property, and was inspected at a later date and is discussed in a separate report.

b. Project Geology. Thin residual soils cover bedrock of Cambrian age in the vicinity of the lakes. Spillway outlet channels of both dams are cut in fine to medium-grained brown sandstone. The right downstream abutment of Butterfly Dam is formed against a near-vertical rock bluff.

c. Dams. No detrimental settlement, cracks, active slides or sinkholes were observed in or near the embankment. Embankment cross-sections near the maximum height section for each dam are shown on PLATES 3 and 4. These slopes are typical of the overall embankments. An old, healed slide is present on the downstream face of Butterfly Dam at the location of the surveyed section. The owner's engineer has installed 6 piezometers in this section and a row of horizontally aligned metal posts along the mid-slope to monitor movement.

A small seep with an area of cattails about 5 feet square was noted along the right downstream abutment of Butterfly Dam. This seep may be a natural spring from the adjacent rock bluff which was blocked by the embankment. Embankment seepage at Butterfly Dam was corrected in 1973 by installation of a drainage system on the west side. The drainage system outlet was found to be in good condition and not flowing. A trace of silt was present in the bottom of the pipe. No seepage was observed on Rainbow Dam.

At both Butterfly and Rainbow dams, the next lake downstream is near or at the dam toe; however, the lower pools do not submerge the embankment since bedrock foundation generally outcrops at this same location.

Some minor erosion was noted on both dams. A major erosion problem on the right abutment of Butterfly Dam was corrected in 1973 by adding fill and diverting road drainage to a new storm drain along the embankment face.

Both embankments had scattered light brush on the downstream face in addition to the desired turf. If left uncontrolled, such growth could eventually include trees and be a potential seepage hazard. The upstream faces had generally heavier brush and a few small trees. The crown of Rainbow Dam had tall grass and the slopes evidenced less maintenance than Butterfly Dam. The lack of maintenance may be related to the dual ownership of the dam discussed in Section 1.

Based on surface observation, the dams are composed of brown, sandy clays from residual soils in the immediate vicinity. Small rocks are also present.

Small riprap, less than 12 inches, and generally below 6 inches in diameter, is present over much of the upstream slopes, but does not provide complete, uniform coverage. No significant wave erosion was observed; both lakes are short and protected against winds by surrounding hilly topography.

d. Appurtenant Structures. Butterfly Dam has a spillway in the left abutment consisting of six 24-inch corrugated metal pipes with a concrete headwall at either end. During the 1973 repairs, a void beneath the spillway was filled with concrete and a short downstream apron was added. The outlet channel is cut in brown sandstone. A number of small trees are growing up in the outlet channel. The outlet channel is adjacent to the embankment and large flows could threaten erosion of the embankment materials. A flow less than 1 cubic foot per second was occurring at the time of the inspection.

An emergency spillway is being constructed by cutting through and lowering a road along the western extension of the dam axis.

Rainbow Lake has a spillway in the right abutment consisting of four 50- by 31-inch corrugated-metal pipe arches with concrete headwalls. The outflow passes over a recently-constructed short concrete apron and into an outlet channel of brown sandstone. Similar to Butterfly Dam above, large spillway flows could threaten embankment erosion. Trees and dense brush are present in the spillway approach channel and restrict its usefulness.

e. Reservoir Areas. No pertinent problems were noted.

f. Downstream Channel. Both dams have another lake immediately downstream of the rock cut outlet channels discussed above.

3.2 EVALUATION.

Several items are deficient which should be corrected. Brush and small trees on the downstream slope need to be removed on both dams. Riprap or other erosion protection at spillway/embankment interface is needed. Maintenance on downstream slope of Rainbow Dam needs to be increased.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

Operational procedures are nonexistent since the dams have uncontrolled spillways.

4.2 MAINTENANCE OF DAM

An effort at maintenance is evident by the magnitude of past repairs, absence of large trees or erosion, etc. As previously discussed, maintenance at Rainbow Dam is somewhat poorer than at Butterfly Dam. With mowing and removal of brush on embankments and in spillways, maintenance would be considered good.

4.3 MAINTENANCE OF OPERATING FACILITIES

Not applicable.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

No warning system is known to exist.

4.5 EVALUATION

Additional maintenance in the form of mowing and clearing brush from the embankments and spillways is recommended. However, it was evident that the owners have an obvious interest in maintaining the integrity of the dams, as evidenced by their accomplishing major repairs of Butterfly Lake Dam and monitoring the structure under the direction of an engineer.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. A design drawing prepared for a repair contract on Butterfly Lake Dam was provided by the owner. This sheet was a contour map of Butterfly Dam at a contour interval of 1 foot prepared by M. B. Corlew & Associates, Inc. No original design data are available for Rainbow Lake Dam.

b. Experience Data. The drainage area and lake surface area were developed from USGS Sprott and South West Weingarten, Missouri 7-1/2 Minute Quadrangle Maps. The spillway and outlet data were surveyed during the inspection.

c. Visual Observations.

(1) No drawdown facilities are available to evacuate the pool of either Butterfly or Rainbow Lakes.

(2) Low Level Outlets.

(a) The outlet works for Butterfly Lake consists of six 24-inch corrugated metal pipes located at the left end of the dam embankment. The inlet invert elevation is at 802.15 feet. The outlet invert is at 801.71 feet. The tailwater flows through a steep channel cut through rock in the left abutment of the dam. The inlet and outlet of the culvert spillway are protected by concrete head-and-wing walls. Some erosion was noted at the right hand downstream wing wall. The owner's representative stated an intention to provide future protection. (See photographs 7 and 8.)

b. The outlet works for Rainbow Lake consisted of four corrugated metal arches with a span of 50 inches and a rise of 31 inches, located at the right side of the dam embankment. The inlet invert elevation is 765.56 feet. The outlet invert elevation is 765.26 feet. The tailwater flows through a steep channel cut in the rock of the right abutment of the dam. The entrance and outlet have concrete head-and-wing walls. (See photographs 16 and 17.)

(3) Butterfly Lake's emergency spillway is located on the extreme left abutment. The spillway consists of a low natural saddle. The owner has partially degraded a previously placed road fill in the spillway area. Rock is still visible throughout the spillway area. See the profile of the dam. (See photographs 9 and 18.) Flow over the spillway will exit down a small valley that empties into Rainbow Lake. The spillway is judged to be sufficiently stable to pass overflows below the minimum elevation of the earth embankment.

(4) Rainbow Lake's spillway located in the right abutment, adjoining the low head outlets, had small trees growing along the upstream side of it. Spillway consisted of a low section of the dam with a concrete slab as part of it. The concrete slab is arched on the ends. (See photographs 12 and 18.) See the location of the spillway on PLATE 4. The spillway area that was not covered with concrete was generally rock. As discussed in Section 3, large spillway flows could induce erosion of the adjacent embankment.

d. Overtopping Potential.

(1) Butterfly Lake Dam will be overtopped by any flood greater than 20 percent of the Probable Maximum Flood (PMF). The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway section and culverts will pass the 1 percent frequency flood without overtopping the dam. Routing the PMF through the reservoir reveals that the dam would be overtopped for approximately 5.6 hours; depth of overtopping would be approximately 3.1 feet and the maximum discharge approximately 15,900 cfs. A 1 percent frequency flood is a flood with a 1 percent chance of being exceeded in any given year.

(2) Rainbow Lake Dam will be overtopped by any flood greater than 15 percent of the Probable Maximum Flood. Routing the PMF through the reservoir reveals that the dam would be overtopped for approximately 7.4 hours; depth of overtopping would be approximately 4.1 feet and the maximum discharge approximately 23,300 cfs. Rainbow Lake will not pass the 1 percent frequency flood without overtopping.

(3) Since the outlet facilities for Butterfly Lake and Rainbow Lake Dams will not pass one-half (50 percent) of the PMF without overtopping the dam and causing failure, the outlet facilities are considered seriously inadequate.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of the dams and spillways are discussed and evaluated in Sections 3 and 5.

b. Design and Construction Data. These data are discussed in Section 2. While original data on the two dams are not known to be available, substantial data are available for the remedial work done in 1973 to Butterfly Dam. Pertinent data are included in the appendix. Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be rectified.

c. Operating Records. See paragraph 2.3.

d. Post-Construction Changes. Major rehabilitation of Butterfly Dam was accomplished in 1973. The work included restoration of an eroded area, installation of embankment drains to control seepage, filling of cracks, spillway repairs, and installation of pore pressure and movement instrumentation.

e. Seismic Stability. Both dams are located in Seismic Zone 2, to which the recommended guidelines assign a "moderate" damage probability. The relatively low dam heights and clayey embankment materials minimize the likelihood of dam failure due to earthquake.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Based on visual inspection and review of available data, the dams appear to be stable and in generally good condition. Brush on embankments constitutes a potential seepage hazard and provides animal habitat. The spillway on Butterfly Dam is inadequate to pass the Probable Maximum Flood (PMF) without overtopping the dam. The spillway on Rainbow Dam is inadequate to pass the Probable Maximum Flood without overtopping the dam.

b. Adequacy of Information. The statements and records herein are based on visual data and information furnished by the owner and the owner's engineer. Butterfly Dam has been repaired based on recommendations by the engineer and has been provided instrumentation for monitoring.

Stability and seepage analyses comparable to the requirements of the guidelines (except for the previous condition of Butterfly Dam) are not on record. This is a deficiency which should be rectified.

c. Urgency. It is recommended that the remedial measures listed in Section 7.2 be accomplished in the near future. The item recommended in paragraph 7.2c should be pursued on a high-priority basis.

d. Necessity for Phase II. No Phase II inspection is recommended. Action should begin on the remedial actions discussed in this report.

7.2 REMEDIAL MEASURES

The following remedial measures are recommended:

a. Remove brush and mow embankments and the crown of Rainbow Dam. Fill any holes or burrows found.

b. Continue the present program of monitoring on Butterfly Dam and periodic evaluation of both dams by an engineer. The owner (River Bluffs Girl Scout Council) is commended for their interest in insuring the safety of their structures by periodic engineering evaluation.

c. Spillway capacity and/or height of each dam should be increased to pass the PMF (Butterfly, 100 percent PMF, Rainbow 100 percent PMF) without overtopping the dam.

d. Operation and Maintenance Procedures.

(1) Removal of the trees from the entrance of Rainbow Lake spillway would increase the capacity of the spillway as an interim measure.

(2) Placement of riprap or other protection on the banks at the ends of the wing walls on the tailwater side at both dams. This will minimize the hazard of embankment erosion.

(3) Complete removal of the earthfill from Butterfly Lake's emergency spillway which will increase its capacity as an interim measure.

(4) Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of dams.

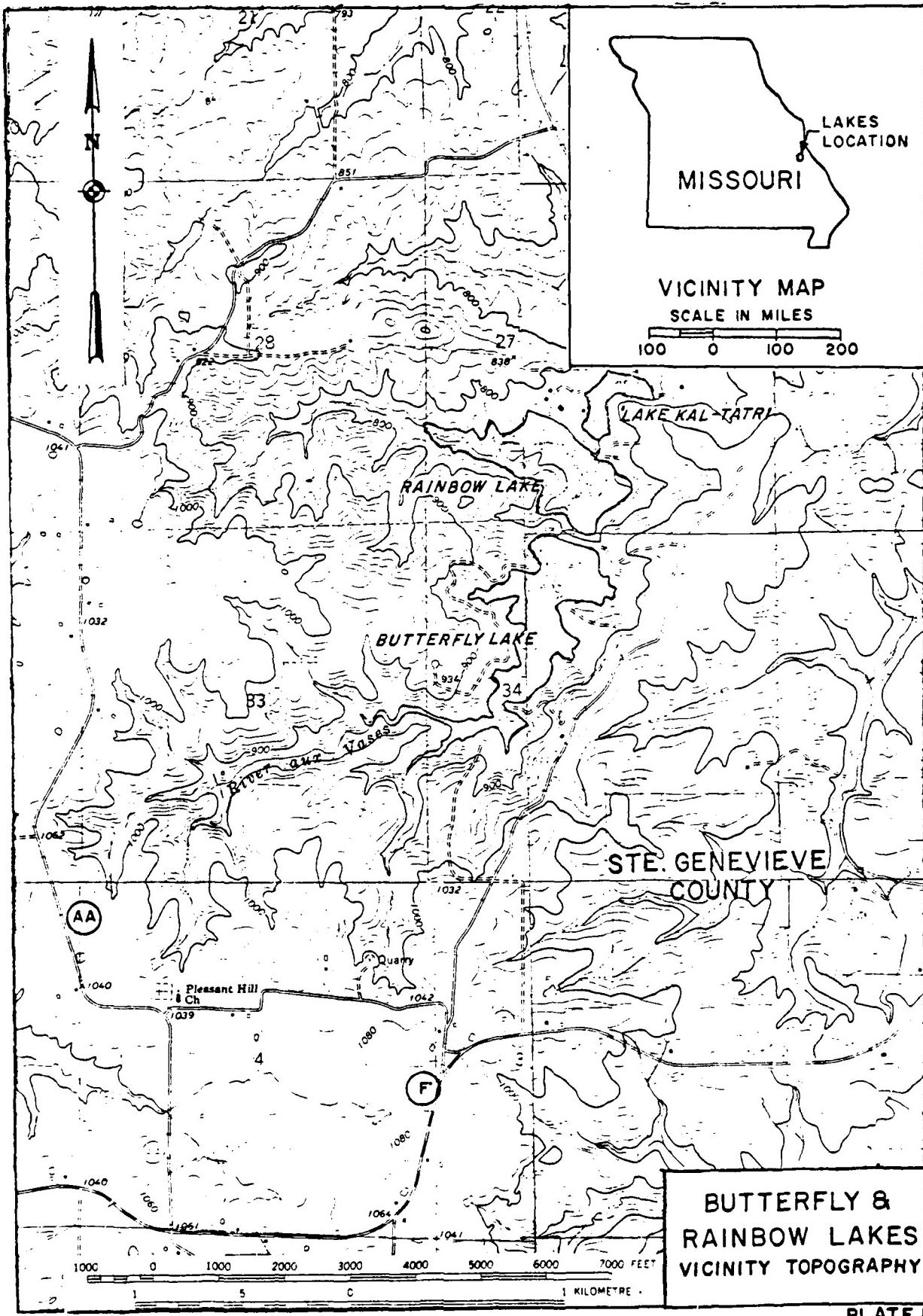


PLATE 2

BUTTERFLY LAKE
DAM PROFILE

0' - 100' 100' - 200' 200' - 300' 300' - 400' 400' - 500' 500' - 600'

BUTTERFLY LAKE DAM PROFILE

10-351 TOP SPILLWAY - 805.6 ft - 303.6
10-344 TOP SPILLWAY - 805.6 ft - 303.6
10-345 SPILLWAY - 802.0 ft - 300.0 ft

10-345 SPILLWAY - 802.0 ft - 300.0 ft

2418 STORM DRAIN P/L = 810.36

-35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35

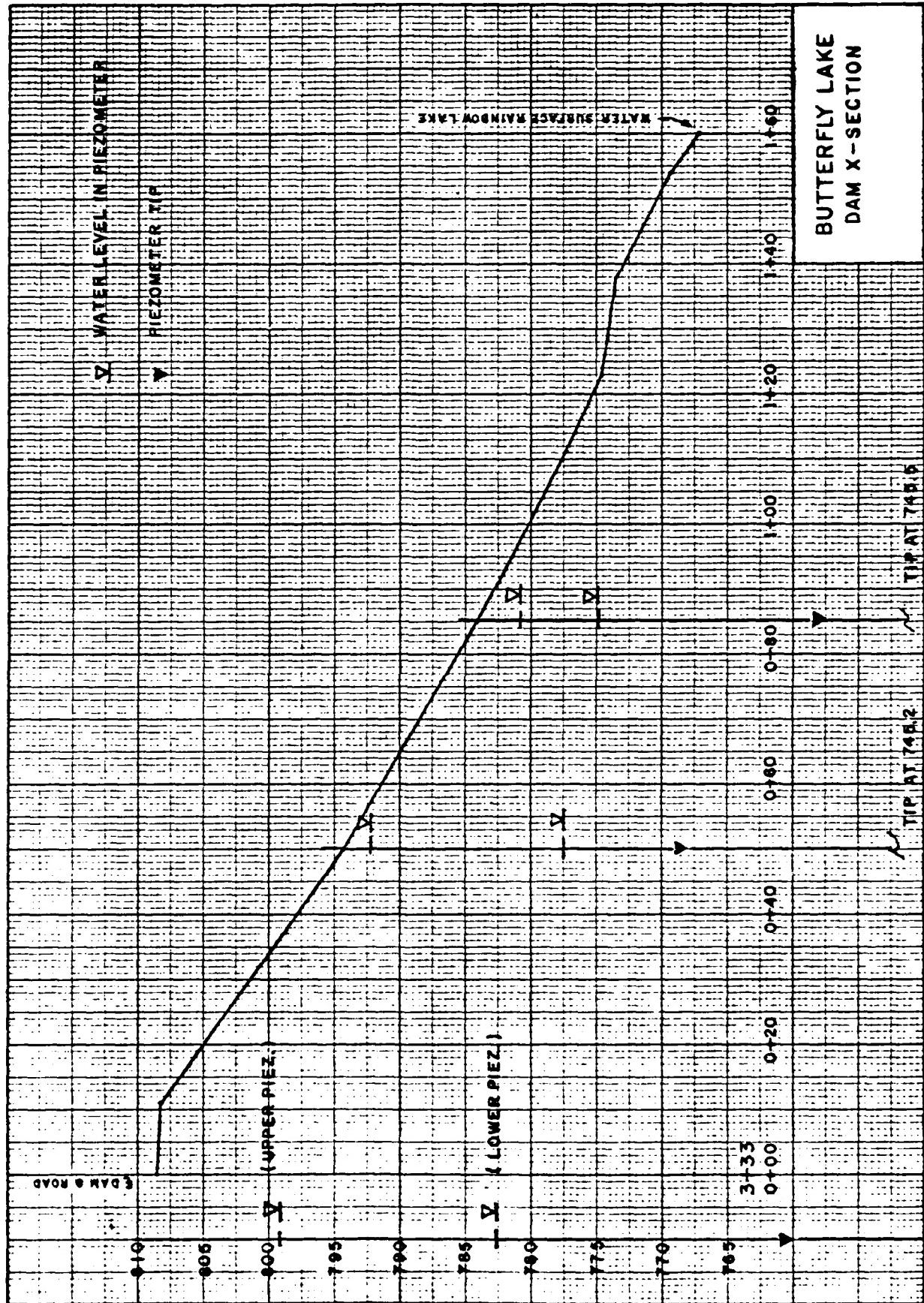


PLATE 4

RAINBOW LAKE
PROFILE AND X-SEC.

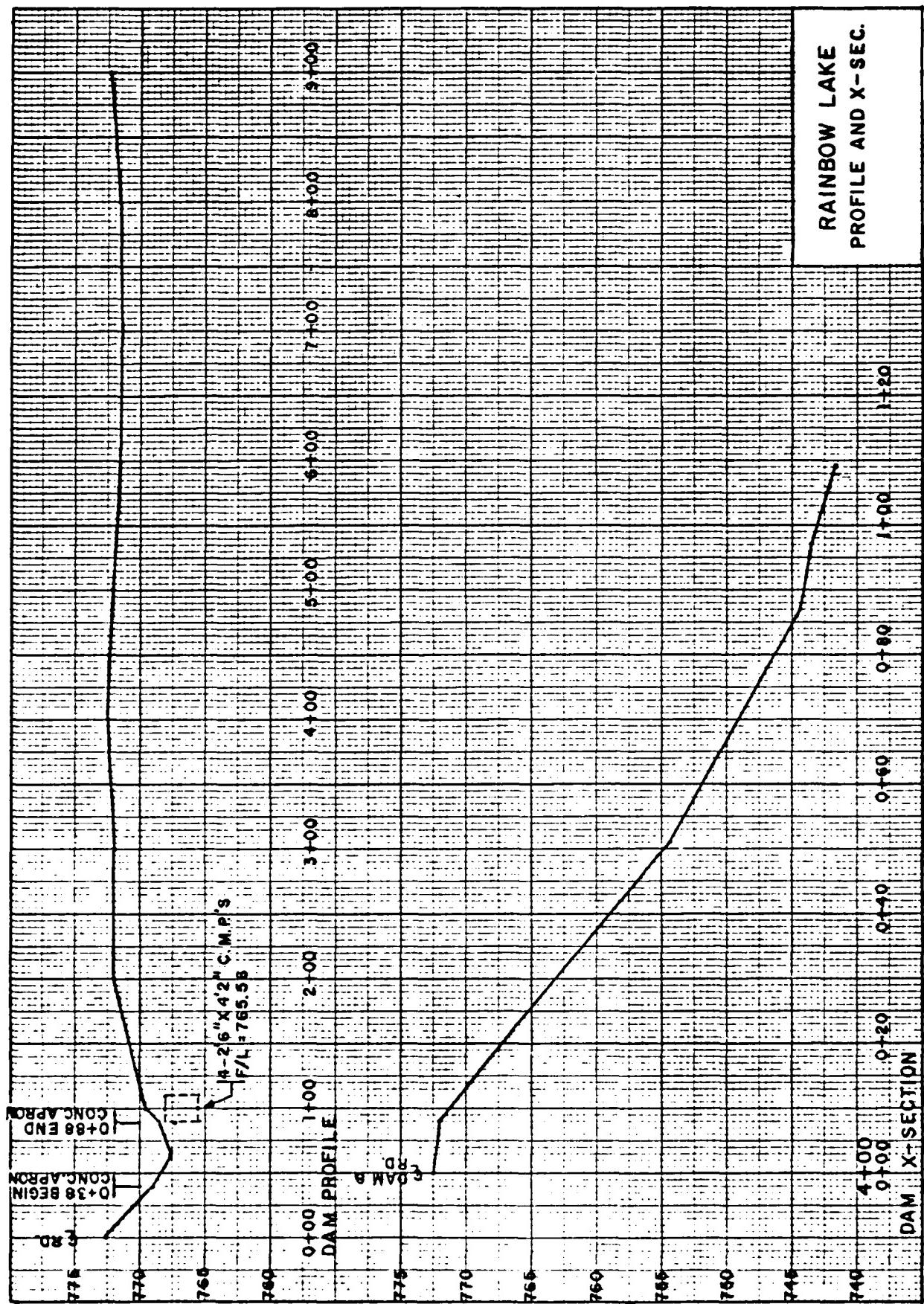




PHOTO 1

Butterfly Dam



PHOTO 2

Butterfly Dam -
Downstream Slope



PHOTO 3 Butterfly Dam - Upstream Slope

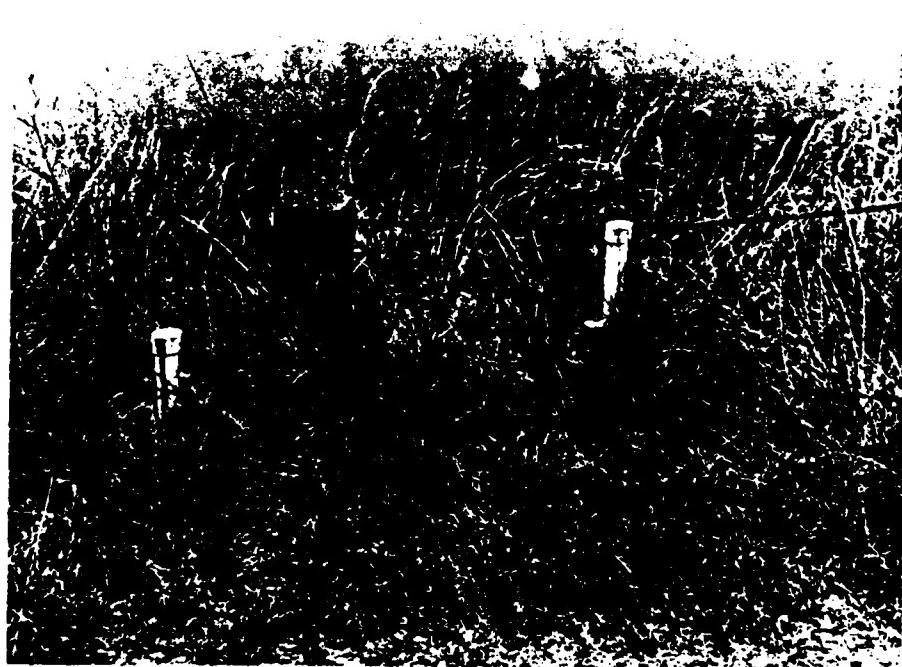


PHOTO 4 Butterfly Dam - Thermometers



PHOTO 5 Butterfly Dam - Steep in
Right Abutment

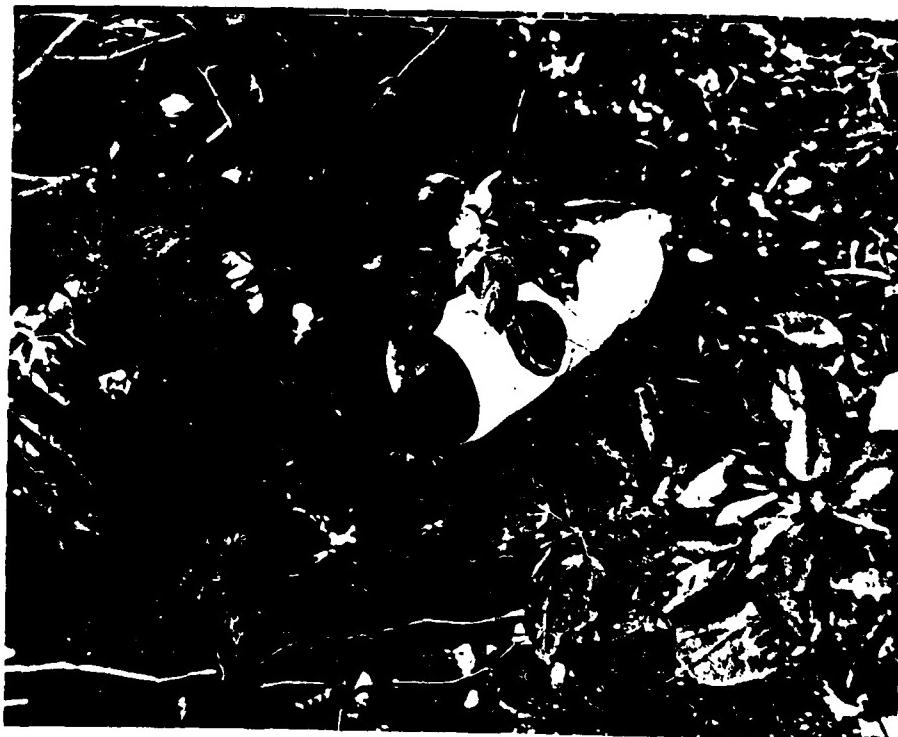


PHOTO 6 Butterfly Dam - Drainage
System Outlet



PHOTO 7 Butterfly Dam - Outlet Channel



PHOTO 8 Butterfly Dam - Outlet



PHOTO 2
Butterfly Dam - Emergency
Spillway



PHOTO 1
Butterfly Dam - d.s. side,
Emergency Spillway



PHOTO 11 Rainbow Lake



PHOTO 12 Rainbow Dam, Emergency Spillway in Foreground

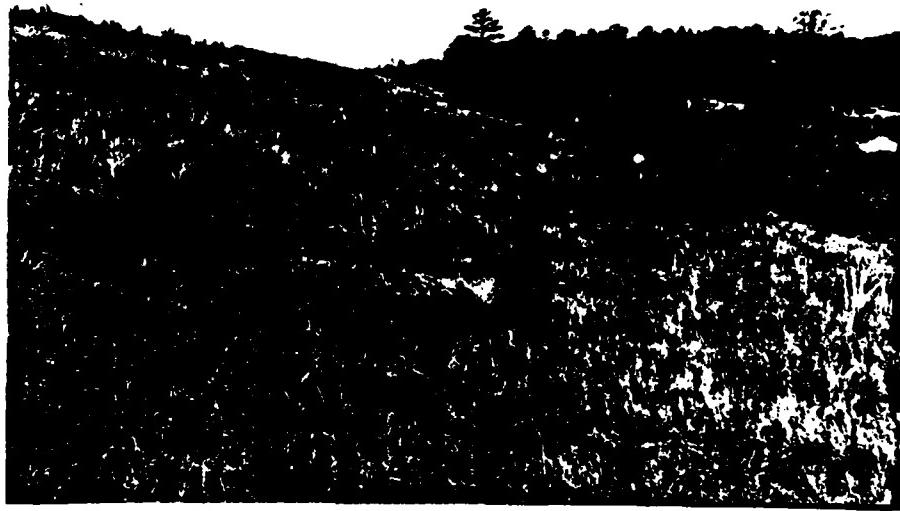


PHOTO 13 Rainbow Dam - Downstream
Slope



PHOTO 14 Rainbow Dam - Downstream
Slope



PHOTO 15 Rainbow Dam - Upstream Slope

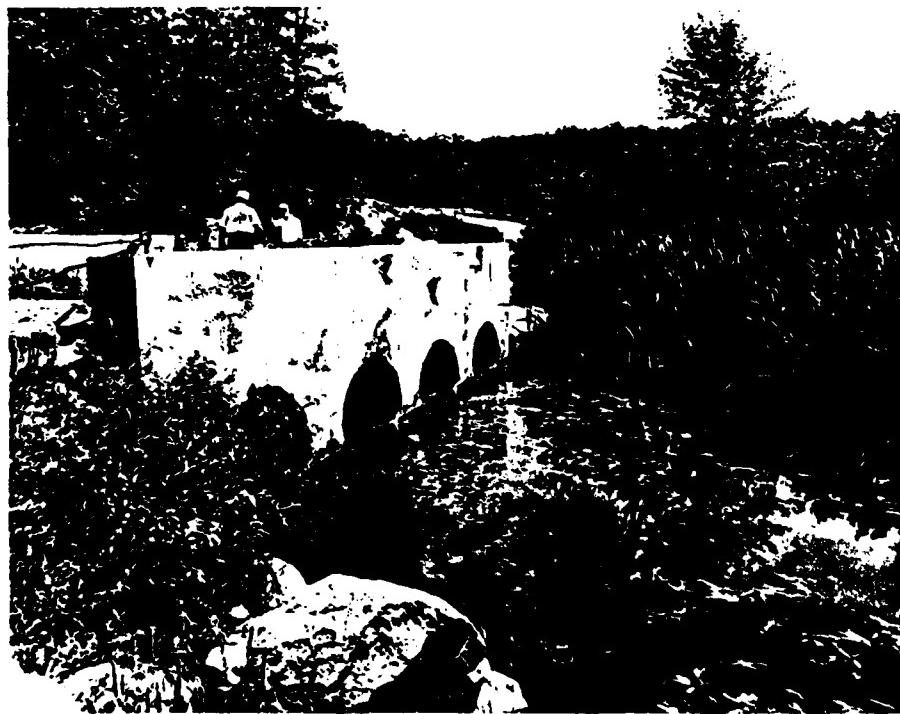


PHOTO 16 Rainbow Dam - Upstream Side
of Outlet



PHOTO 17 Rainbow Dam - Downstream Side
of Outlet



PHOTO 18 Rainbow Dam - Spillway and
Outlet Channel.

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSIS METHODOLOGY

HYDROLOGIC AND HYDRAULIC ANALYSIS METHODOLOGY

1. The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for a reservoir routing. The Probable Maximum Precipitation is derived and determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors have not been applied. A 24-hour storm duration is assumed with the total rainfall depth distributed over 6-hour periods in accordance with procedures outlined in EM 1110-2-1411 (SPF Determination). The maximum 6-hour rainfall period is then distributed to hourly increments by the same criteria. Within-the-hour distribution is based upon NOAA Technical Memorandum NWS HYDRO-35. The non-peak 6-hour rainfall periods are distributed uniformly. All distributed values are arranged in a critical sequence by the SPF criteria. The final inflow hydrograph is produced by deduction of infiltration losses appropriate to the soil, land use, and antecedent moisture conditions.
2. The reservoir routing is accomplished by using Modified Puls routing techniques wherein the flood hydrograph is routed through lake storage. Hydraulic capacities of the outlet works, spillway, and crest of dam are used as outlet controls in the routing. Storage in the pool area is defined by an elevation-storage capacity curve. The hydraulic capacity of the outlet works, spillway, and top of dam are defined by elevation-discharge curves.
3. Dam overtopping analysis has been conducted by hydrologic methods for this dam and lake. This computation determines the percentage of the PMF hydrograph that the reservoir can contain without the dam being overtopped. An output summary in the hydrologic appendix displays this information as well as other characteristics of the simulated dam overtopping.
4. The above methodology has been accomplished for this report using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The numeric parameters estimated for this site are listed in the attached computer printout. Definitions of these variables are contained in the "User's Manual" for the computer program.

		DAH			INSPECTION			
		A	RAINBOW	AND	BUTTERFLY		LAKES	
		A	PROBABLE	MAXIMUM	FLOOD		FLOOD	
1								
2								
3								
4								
5		R1	5	0	5	0	0	-3 0
6		J	1	9	1			
7		J1	.10	.15	.20	.25	.30	.40
8		K	0	1	0	0	0	.45 .50 .1.0
9		K1	SUBAREA	RUNOFF	FOR	BUTTERFLY	LAKE	
10		P	1	2	1,63	0	0	1.0
11		P	0	.26	100	120	130	
12		T	0	0	0	0	0	
13		W2	0	.25				
14		X	-10	=.1	3.0			
15		K	1	2				
16		K1	RESERVOIR	ROUTING	FOR	BUTTERFLY	LAKE	
17		Y				0	0	
18		Y1	1				1	0
19		Y4	.002	.004	.005	.006	.009	-803.5 -1
20		Y5	0	.73	.219	4.11	809	810
21		SA	0	.67	.95	1975	4310	8774
22		SE	.742	.802	.820			14895 22233 30607
23		SS	803.5					
24		SD	808					
25		K	0	3	0	0	0	1
26		K1	SUBAREA	RUNOFF	FOR	RAINBOW	LAKE	
27		H	1	2	.89	0	0	1.0
28		P	0	.26	.100	.120	.130	
29		T	0	0	0	0	0	
30		W2	0	.23				
31		X	-10	=.1	3.0			
32		K	2	4				
33		K1	RAINBOW	AND	BUTTERFLY	LAKES	HYDROGRAPHS	COMBINED
34		K	1	5	0	0	0	1
35		K1	RESERVOIR	ROUTING	OP	BUTTERFLY	AND	RAINBOW
36		Y			1	1		
37		Y1	1					-767.7 -1
38		Y4	765.6	.767	.768	.769	.770	771
39		Y5	0	.40	.170	.411	.760	1247 2240
40		SA	0	33	40	0		4828 8711 19603
41		SE	.740	.766	.780			
42		SS	767.7					
43		SD	771.4					
44		K	99					

DAM INSPECTION
RAINBOW AND BUTTERFLY
PROBABLE MAXIMUM FLOOD

JOB SPECIFICATION

NQ	MUR	MMIN	IDAY	IIR	IMIN	METRC	IPLT	IPRT	NSTAN
246	0	5	0	0	0	0	0	3	0
JOPER NWT LROPT TRACE									
5	0	0	0	0	0	0	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED

RTIOS-	.10	.15	.20	.25	.30	.40	.45	.50	1.00
NPLAN-1-NPTION-9-LPTION-1									

SUB-AREA RUNOFF COMPUTATION

SUBAREA-RUNOFF-POR-BUTTERFLY-LAKE									
1STAQ	ICOMP	IECON	ITAPE	JPLT	JRTT	I NAME	I STAGE	I AUTO	
1	0	0	0	0	0	1	0	0	0
HYDROGRAPH DATA									
IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	1.63	0.00	1.63	1.00	0.000	0	0	0

PRECIP DATA

SPPE	PMS	P6	P12	R24	R48	R72	R96
0.00	26.00	100.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA									
LROPT	STRKX	DLTMR	ERAIN	STROK	STRTL	CNSTL	ALSMX	RTIMP	
0	0.00	0.00	1.00	0.00	1.00	-1.00	-0.90	0.00	.06
CURVE NO = -89.00 WETNESS = -1.00 EFFECT CN = R9.00									

UNIT HYDROGRAPH DATA

TC-	0.00	LAG-	.25
-----	------	------	-----

STRTQ- -10.00 RECEDSION DATA QRCSSH- -.10 RTION- 3.00

UNIT HYDROGRAPH 17 END OF PERIOD ORDINATES, TC=		0.00 HOURS, LAG= .25 VOL=.1.00	
537.	1837.	2924.	228.
134.	84.	53.	33.
			23.
			4.
			13.

849.

550.

342.

214.

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW			PERIOD	RAIN	EXCS	LOSS	COMP Q
						MO.DA	HR.MN	PERIOD					
1.01	.05		.01	.00	.01	17.			1.01	12.05	145	.22	.21
1.01	.10		.01	.00	.01	17.			1.01	12.10	146	.22	.21
1.01	.15	3	.01	.00	.01	18.			1.01	12.15	147	.22	.21
1.01	.20	4	.01	.00	.01	19.			1.01	12.20	148	.22	.21
1.01	.25	5	.01	.00	.01	20.			1.01	12.25	149	.22	.21
1.01	.30	6	.01	.00	.01	20.			1.01	12.30	150	.22	.21
1.01	.35	7	.01	.00	.01	19.			1.01	12.35	151	.22	.21
1.01	.40	8	.01	.00	.01	19.			1.01	12.40	152	.22	.21
1.01	.45	9	.01	.00	.01	19.			1.01	12.45	153	.22	.21
1.01	.50	10	.01	.00	.01	18.			1.01	12.50	154	.22	.21
1.01	.55	11	.01	.00	.01	18.			1.01	12.55	155	.22	.21
1.01	.60	12	.01	.00	.01	17.			1.01	13.00	156	.22	.21
1.01	.65	13	.01	.00	.01	17.			1.01	13.05	157	.26	.26
1.01	.70	14	.01	.00	.01	16.			1.01	13.10	158	.26	.26
1.01	.75	15	.01	.00	.01	16.			1.01	13.15	159	.26	.26
1.01	.80	16	.01	.00	.01	15.			1.01	13.20	160	.26	.26
1.01	.85	17	.01	.00	.01	15.			1.01	13.25	161	.26	.26
1.01	.90	18	.01	.00	.01	15.			1.01	13.30	162	.26	.26
1.01	.95	19	.01	.00	.01	15.			1.01	13.35	163	.26	.26
1.01	1.00	20	.01	.00	.01	16.			1.01	13.40	164	.26	.26
1.01	1.05	21	.01	.00	.01	18.			1.01	13.45	165	.26	.26
1.01	1.10	22	.01	.00	.01	20.			1.01	13.50	166	.26	.26
1.01	1.15	23	.01	.00	.01	23.			1.01	13.55	167	.26	.26
1.01	1.20	24	.01	.00	.01	27.			1.01	14.00	168	.26	.26
1.01	1.25	24	.01	.00	.01	30.			1.01	14.05	169	.33	.32
1.01	1.30	25	.01	.00	.01	33.			1.01	14.10	170	.33	.32
1.01	1.35	26	.01	.00	.01	37.			1.01	14.15	171	.33	.32
1.01	1.40	27	.01	.00	.01	40.			1.01	14.20	172	.33	.32
1.01	1.45	27	.01	.00	.01	44.			1.01	14.25	173	.33	.32
1.01	1.50	28	.01	.00	.01	44.			1.01	14.30	174	.33	.32
1.01	1.55	29	.01	.00	.01	47.			1.01	14.35	175	.33	.32
1.01	1.60	29	.01	.00	.01	50.			1.01	14.40	176	.33	.32
1.01	1.65	30	.01	.00	.01	53.			1.01	14.45	177	.33	.32
1.01	1.70	30	.01	.00	.01	56.			1.01	14.50	178	.33	.32
1.01	1.75	31	.01	.00	.01	59.			1.01	14.55	179	.33	.32
1.01	1.80	31	.01	.00	.01	62.			1.01	14.60	180	.33	.32
1.01	1.85	32	.01	.00	.01	65.			1.01	14.65	181	.33	.32
1.01	1.90	32	.01	.00	.01	68.			1.01	15.05	181	.20	.20
1.01	1.95	33	.01	.00	.01	70.			1.01	15.10	182	.40	.39
1.01	2.00	33	.01	.00	.01	73.			1.01	15.15	183	.40	.39
1.01	2.05	34	.01	.00	.01	73.			1.01	15.20	184	.39	.39
1.01	2.10	34	.01	.00	.01	75.			1.01	15.25	185	.39	.39
1.01	2.15	35	.01	.00	.01	76.			1.01	15.30	185	.32	.32
1.01	2.20	35	.01	.00	.01	80.			1.01	15.30	186	.69	.69
1.01	2.25	36	.01	.00	.01	83.			1.01	15.35	187	1.68	1.68
1.01	2.30	36	.01	.00	.01	85.			1.01	15.40	188	1.09	1.08
1.01	2.35	37	.01	.00	.01	87.			1.01	15.45	189	.69	.69
1.01	2.40	37	.01	.00	.01	89.			1.01	15.50	190	.59	.59
1.01	2.45	38	.01	.00	.01	91.			1.01	15.55	191	.40	.39
1.01	2.50	38	.01	.00	.01	93.			1.01	16.00	192	2.76	2.76
1.01	2.55	39	.01	.00	.01	95.			1.01	16.05	193	.30	.30
1.01	2.60	39	.01	.00	.01	97.			1.01	16.10	194	.30	.30
1.01	2.65	40	.01	.00	.01	98.			1.01	16.15	195	.30	.30
1.01	2.70	41	.01	.00	.01	99.			1.01	16.20	196	.30	.30
1.01	2.75	42	.01	.00	.01	101.			1.01	16.25	197	.30	.30
1.01	3.00	42	.01	.00	.01	101.			1.01	16.30	198	.30	.30
1.01	3.05	43	.01	.00	.01	102.			1.01	16.35	199	.30	.30
1.01	3.10	43	.01	.00	.01	103.			1.01	16.40	200	.30	.30
1.01	3.15	44	.01	.00	.01	104.			1.01	16.45	201	.30	.30
1.01	3.20	44	.01	.00	.01	105.			1.01	16.50	202	.30	.30
1.01	3.25	45	.01	.00	.01	106.			1.01	16.55	203	.30	.30
1.01	3.30	45	.01	.00	.01	107.			1.01	16.60	204	.30	.30
1.01	3.35	46	.01	.00	.01	108.			1.01	16.65	205	.30	.30
1.01	3.40	46	.01	.00	.01	109.			1.01	16.70	206	.30	.30
1.01	3.45	47	.01	.00	.01	110.			1.01	16.75	207	.30	.30
1.01	3.50	47	.01	.00	.01	111.			1.01	16.80	208	.30	.30
1.01	3.55	48	.01	.00	.01	112.			1.01	16.85	209	.30	.30
1.01	3.60	48	.01	.00	.01	113.			1.01	16.90	210	.30	.30
1.01	3.65	49	.01	.00	.01	114.			1.01	16.95	211	.30	.30
1.01	3.70	49	.01	.00	.01	115.			1.01	17.00	212	.30	.30
1.01	3.75	50	.01	.00	.01	116.			1.01	17.05	213	.30	.30
1.01	3.80	51	.01	.00	.01	117.			1.01	17.10	214	.30	.30
1.01	3.85	51	.01	.00	.01	118.			1.01	17.15	215	.30	.30
1.01	3.90	52	.01	.00	.01	119.			1.01	17.20	216	.30	.30
1.01	3.95	52	.01	.00	.01	120.			1.01	17.25	217	.30	.30
1.01	4.00	53	.01	.00	.01	121.			1.01	17.30	218	.30	.30
1.01	4.05	53	.01	.00	.01	122.			1.01	17.35	219	.30	.30
1.01	4.10	54	.01	.00	.01	123.			1.01	17.40	220	.30	.30
1.01	4.15	54	.01	.00	.01	124.			1.01	17.45	221	.30	.30
1.01	4.20	55	.01	.00	.01	125.			1.01	17.50	222	.30	.30
1.01	4.25	55	.01	.00	.01	126.			1.01	17.55	223	.30	.30
1.01	4.30	56	.01	.00	.01	127.			1.01	17.60	224	.30	.30

1.01	4.15	.55	.01	.01	1.06	1.01	16.35	1.99	.30	.30	.00	4.7
1.01	4.40	.56	.01	.01	1.07	1.01	16.40	2.00	.30	.30	.00	4.572.
1.01	4.45	.57	.01	.01	1.08	1.01	16.45	2.01	.30	.30	.00	4.468.
1.01	4.50	.58	.01	.01	1.11	1.01	16.50	2.02	.30	.30	.00	4.393.
1.01	4.55	.59	.01	.01	1.12	1.01	16.55	2.03	.30	.30	.00	4.341.
1.01	4.60	.60	.01	.01	1.14	1.01	17.00	2.04	.30	.30	.00	4.312.
1.01	4.65	.61	.01	.01	1.15	1.01	17.05	2.05	.24	.24	.00	4.265.
1.01	4.70	.62	.01	.01	1.16	1.01	17.10	2.06	.24	.24	.00	4.140.
1.01	4.75	.63	.01	.01	1.18	1.01	17.15	2.07	.24	.24	.00	3.947.
1.01	5.20	.64	.01	.01	1.19	1.01	17.20	2.08	.24	.24	.00	3.757.
1.01	5.25	.65	.01	.01	1.20	1.01	17.25	2.09	.24	.24	.00	3.608.
1.01	5.30	.66	.01	.01	1.22	1.01	17.30	2.10	.24	.24	.00	3.520.
1.01	5.35	.67	.01	.01	1.23	1.01	17.35	2.11	.24	.24	.00	3.465.
1.01	5.40	.68	.01	.01	1.24	1.01	17.40	2.12	.24	.24	.00	3.429.
1.01	5.45	.69	.01	.01	1.25	1.01	17.45	2.13	.24	.24	.00	3.407.
1.01	5.50	.70	.01	.01	1.27	1.01	17.50	2.14	.24	.24	.00	3.393.
1.01	5.55	.71	.01	.01	1.28	1.01	17.55	2.15	.24	.24	.00	3.365.
1.01	6.00	.72	.01	.01	1.29	1.01	18.00	2.16	.24	.24	.00	3.379.
1.01	6.05	.73	.01	.01	1.31	1.01	18.05	2.17	.02	.02	.00	3.260.
1.01	6.10	.74	.01	.01	1.32	1.01	18.10	2.18	.02	.02	.00	2.860.
1.01	6.15	.75	.01	.01	1.33	1.01	18.15	2.19	.02	.02	.00	2.226.
1.01	6.20	.76	.01	.01	1.34	1.01	18.20	2.20	.02	.02	.00	1.777.
1.01	6.25	.77	.01	.01	1.35	1.01	18.25	2.21	.02	.02	.00	1.592.
1.01	6.30	.78	.01	.01	1.36	1.01	18.30	2.22	.02	.02	.00	1.426.
1.01	6.35	.79	.01	.01	1.37	1.01	18.35	2.23	.02	.02	.00	1.278.
1.01	6.40	.80	.01	.01	1.38	1.01	18.40	2.24	.02	.02	.00	1.145.
1.01	6.45	.81	.01	.01	1.39	1.01	18.45	2.25	.02	.02	.00	1.026.
1.01	6.50	.82	.01	.01	1.40	1.01	18.50	2.26	.02	.02	.00	919.
1.01	6.55	.83	.01	.01	1.41	1.01	18.55	2.27	.02	.02	.00	824.
1.01	7.00	.84	.01	.01	1.43	1.01	18.60	2.28	.02	.02	.00	738.
1.01	7.05	.85	.01	.01	1.43	1.01	19.05	2.29	.02	.02	.00	661.
1.01	7.10	.86	.01	.01	1.44	1.01	19.10	2.30	.02	.02	.00	592.
1.01	7.15	.87	.01	.01	1.45	1.01	19.15	2.31	.02	.02	.00	531.
1.01	7.20	.88	.01	.01	1.45	1.01	19.20	2.32	.02	.02	.00	475.
1.01	7.25	.89	.01	.01	1.45	1.01	19.25	2.33	.02	.02	.00	426.
1.01	7.30	.90	.01	.01	1.46	1.01	19.30	2.34	.02	.02	.00	382.
1.01	7.35	.91	.01	.01	1.47	1.01	19.35	2.35	.02	.02	.00	342.
1.01	7.40	.92	.01	.01	1.47	1.01	19.40	2.36	.02	.02	.00	307.
1.01	7.45	.93	.01	.01	1.48	1.01	19.45	2.37	.02	.02	.00	307.
1.01	7.50	.94	.01	.01	1.48	1.01	19.50	2.38	.02	.02	.00	307.
1.01	7.55	.95	.01	.01	1.49	1.01	19.55	2.39	.02	.02	.00	307.
1.01	8.00	.96	.01	.01	1.50	1.01	20.00	2.40	.02	.02	.00	307.
1.01	8.05	.97	.01	.01	1.50	1.01	20.05	2.41	.02	.02	.00	307.
1.01	8.10	.98	.01	.01	1.51	1.01	20.10	2.42	.02	.02	.00	307.
1.01	8.15	.99	.01	.01	1.51	1.01	20.15	2.43	.02	.02	.00	307.
1.01	8.20	1.00	.01	.01	1.51	1.01	20.20	2.44	.02	.02	.00	307.
1.01	8.25	1.01	.01	.01	1.52	1.01	20.25	2.45	.02	.02	.00	307.
1.01	8.30	1.02	.01	.01	1.52	1.01	20.30	2.46	.02	.02	.00	307.
1.01	8.35	1.03	.01	.01	1.53	1.01	20.35	2.47	.02	.02	.00	307.
1.01	8.40	1.04	.01	.01	1.53	1.01	20.40	2.48	.02	.02	.00	307.
1.01	8.45	1.05	.01	.01	1.54	1.01	20.45	2.49	.02	.02	.00	307.
1.01	8.50	1.06	.01	.01	1.55	1.01	20.50	2.50	.02	.02	.00	307.
1.01	8.55	1.07	.01	.01	1.56	1.01	20.55	2.51	.02	.02	.00	307.
1.01	9.00	1.08	.01	.01	1.56	1.01	21.00	2.52	.02	.02	.00	107.

1.01	9.05	.09	.07	.07	.00	947.	1.01	21.05	253	.02	.02	.00
1.01	9.10	.10	.07	.07	.00	950.	1.01	21.10	254	.02	.02	.00
1.01	9.15	.11	.07	.07	.00	952.	1.01	21.15	255	.02	.02	.00
1.01	9.20	.12	.07	.07	.00	954.	1.01	21.20	256	.02	.02	.00
1.01	- 9.30	.14	.07	.07	.00	958.	1.01	21.30	258	.02	.02	.00
1.01	9.35	.15	.07	.07	.00	960.	1.01	21.35	259	.02	.02	.00
1.01	9.40	.16	.07	.07	.00	962.	1.01	21.40	260	.02	.02	.00
1.01	9.45	.17	.07	.07	.00	964.	1.01	21.45	261	.02	.02	.00
1.01	9.50	.18	.07	.07	.00	965.	1.01	21.50	262	.02	.02	.00
1.01	9.55	.19	.07	.07	.00	967.	1.01	21.55	263	.02	.02	.00
1.01	10.00	.20	.07	.07	.00	969.	1.01	22.00	264	.02	.02	.00
1.01	10.05	.21	.07	.07	.00	970.	1.01	22.05	265	.02	.02	.00
1.01	10.10	.22	.07	.07	.00	971.	1.01	22.10	266	.02	.02	.00
1.01	10.15	.23	.07	.07	.00	973.	1.01	22.15	267	.02	.02	.00
1.01	10.20	.24	.07	.07	.00	974.	1.01	22.20	268	.02	.02	.00
1.01	10.25	.25	.07	.07	.00	975.	1.01	22.25	269	.02	.02	.00
1.01	10.30	.26	.07	.07	.00	977.	1.01	22.30	270	.02	.02	.00
1.01	10.35	.27	.07	.07	.00	978.	1.01	22.35	271	.02	.02	.00
1.01	10.40	.28	.07	.07	.00	979.	1.01	22.40	272	.02	.02	.00
1.01	10.45	.29	.07	.07	.00	980.	1.01	22.45	273	.02	.02	.00
1.01	10.50	.30	.07	.07	.00	981.	1.01	22.50	274	.02	.02	.00
1.01	10.55	.31	.07	.07	.00	982.	1.01	22.55	275	.02	.02	.00
1.01	11.00	.32	.07	.07	.00	983.	1.01	23.00	276	.02	.02	.00
1.01	11.05	.33	.07	.07	.00	984.	1.01	23.05	277	.02	.02	.00
1.01	11.10	.34	.07	.07	.00	985.	1.01	23.10	278	.02	.02	.00
1.01	11.15	.35	.07	.07	.00	986.	1.01	23.15	279	.02	.02	.00
1.01	11.20	.36	.07	.07	.00	987.	1.01	23.20	280	.02	.02	.00
1.01	11.25	.37	.07	.07	.00	988.	1.01	23.25	281	.02	.02	.00
1.01	11.30	.38	.07	.07	.00	989.	1.01	23.30	282	.02	.02	.00
1.01	11.35	.39	.07	.07	.00	990.	1.01	23.35	283	.02	.02	.00
1.01	11.40	.40	.07	.07	.00	991.	1.01	23.40	284	.02	.02	.00
1.01	11.45	.41	.07	.07	.00	992.	1.02	0.00	288	.02	.02	.00
1.01	11.50	.42	.07	.07	.00	993.	1.01	23.50	286	.02	.02	.00
1.01	11.55	.43	.07	.07	.00	994.	1.01	23.55	287	.02	.02	.00
1.01	12.00	.44	.07	.07	.00	995.	1.02	0.00	288	.02	.02	.00

SUM 33.80 32.45 1.35 464534.
(859.) (824.) (34.) (13134.14)

SUMMARY OF DAM SAFETY ANALYSIS

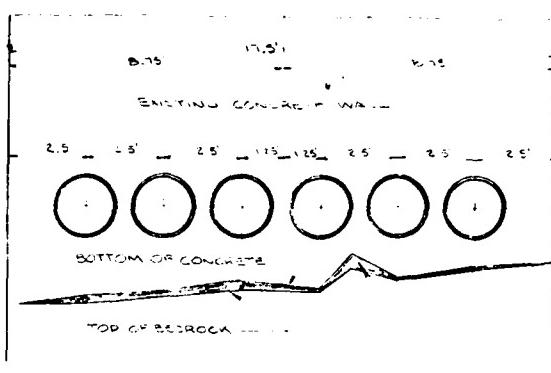
PLAN 1				ELEVATION STORAGE OUTFLOW	INITIAL VALUE 603.50 1442. 55.	SPILLWAY CREST 803.50 1442. 55.	TOP OF DAM 808.00 1708. 1975.
RATIO OF PMP TO W.S.PLEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	DURATION MAX OUTFLOW HOURS	TIME OF FAILURE HOURS	
.10	805.79	0.00	1604.	371.	0.00	17.33	
.15	806.65	0.00	1667.	917.	0.00	16.33	
.20	807.39	0.00	1722.	1509.	0.00	16.25	
.25	808.01	.01	1769.	2005.	.17	16.17	
.30	808.43	.43	1801.	2987.	.83	16.08	
.40	809.12	1.12	1824.	4841.	1.50	16.00	
.45	809.38	1.38	1874.	5984.	1.83	16.00	
.50	809.60	1.60	1891.	6976.	2.25	16.00	
1.00	811.14	3.14	2014.	15935.	5.58	15.92	

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1				ELEVATION STORAGE OUTFLOW	INITIAL VALUE 767.70 343. 131.	SPILLWAY CREST 767.70 343. 131.	TOP OF DAM 771.40 471. 1644.
RATIO OF PMP TO W.S.PLEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	DURATION MAX OUTFLOW HOURS	TIME OF FAILURE HOURS	
.10	769.45	0.00	403.	567.	0.00	17.17	
.15	770.79	0.00	450.	1146.	0.00	16.92	
.20	771.74	.34	463.	1979.	1.42	16.42	
.25	772.32	.92	504.	3056.	2.58	16.17	
.30	772.82	1.42	522.	4354.	3.08	16.08	
.40	773.56	2.16	549.	6990.	4.33	16.08	
.45	773.94	2.54	569.	8483.	4.92	16.00	
.50	774.07	2.67	568.	12762.	5.33	15.92	
1.00	775.50	4.10	621.	23284.	7.42	15.92	

SPILLWAY SECTION

SECTION N-E

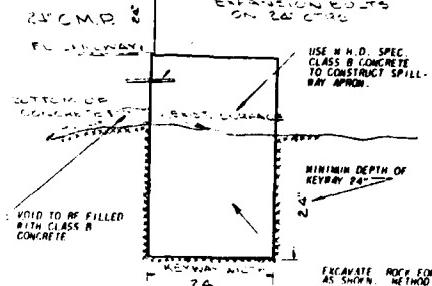


PHASE III CONSISTS OF

1. FILLING VOID BETWEEN ROCK AND SPILLWAY WITH CONCRETE.
2. EXCAVATING KEYWAY IN ROCK AS DIRECTED BY THE ENGINEER.
3. CONSTRUCTING CONCRETE APRON KEYED INTO BEDROCK WITH ANCHORS TO EXISTING SPILLWAY (EXPANSION BOLTS).

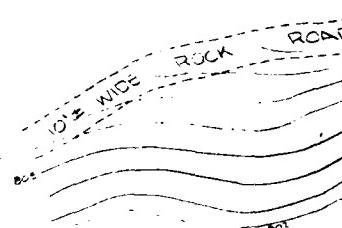
PHASE III

THE CONTRACTOR SHALL FILL THE VOID BETWEEN THE ROCK AND THE EXISTING SPILLWAY WITH CLASS B CONCRETE IN A MANNER SATISFACTORY TO THE ENGINEER. ALL FEATHERED ROCK WHICH IS FOUND IN THE CAVITY AS FAR AS POSSIBLE BE REMOVED FROM THE CAVITY. FOR ROCK REMOVAL NORTH OF EXISTING STRUCTURE, EXTENSION OF SPILLWAY AND OTHER DETAILS, SEE SECTION E-W.



EXCAVATE ROCK FOR KEYWAY AS SHOWN. METHOD OF BLASTING, IF USED, IS SUBJECT TO APPROVAL OF THE ENGINEER.

SECTION E-W



80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

80'-0"

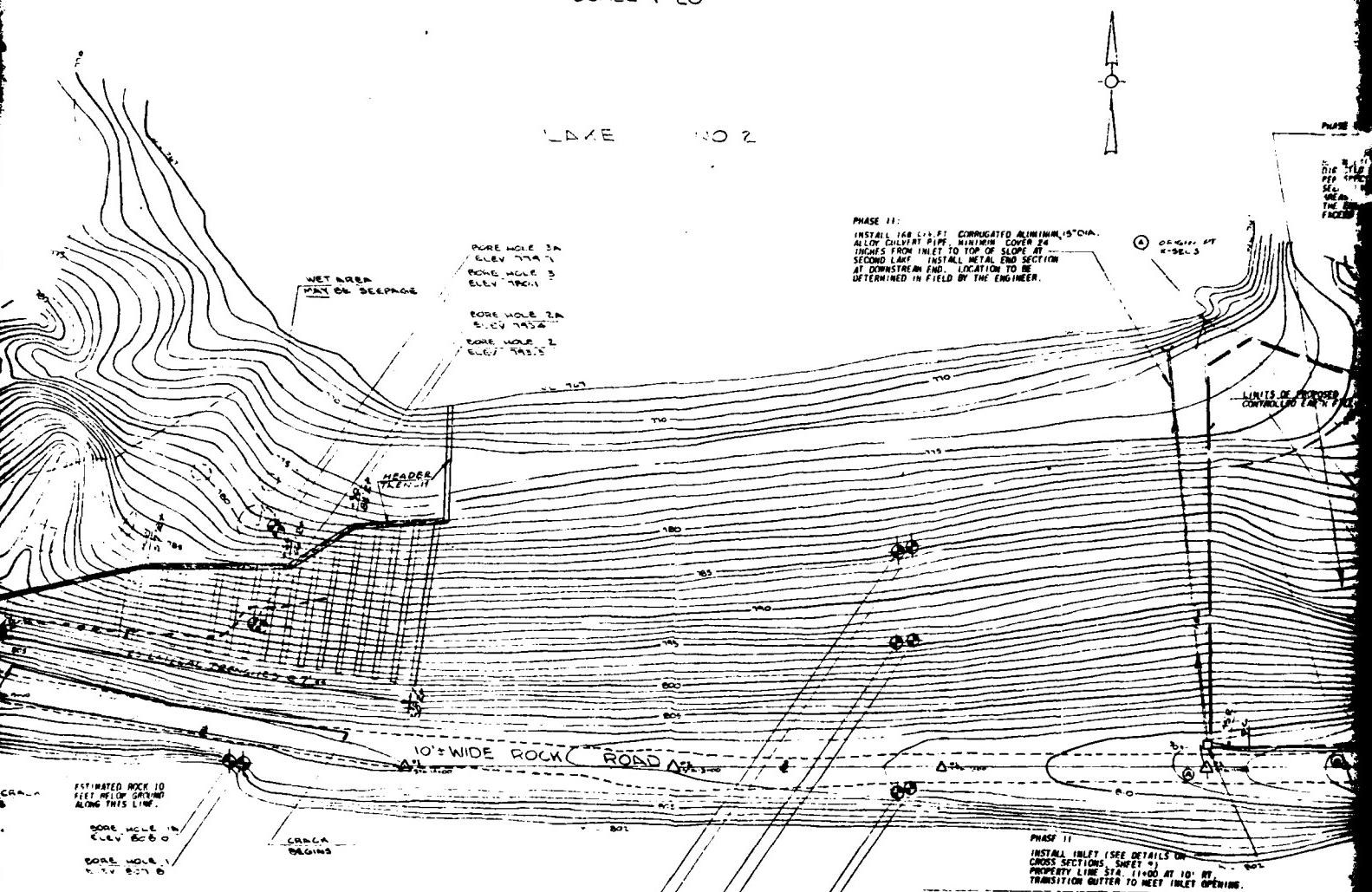
RE-AIMS TO
SUMMERTIME LAKE DAM SITE

FARMINGTON, MISSOURI

M. B. COLEMAN & ASSOCIATES, INC.
ENGINEERS & SURVEYORS
EDWARDSVILLE, ILLINOIS
SEPTEMBER 1973
SCALE 1"-20'

NOTES: CONTOUR
BM ELEV.
PIPE FROM
SPILLWAY

LAKE NO 2



PHASE II:
INSTALL 160 LIN FT CORRUGATED ALUMINUM, 15" O.D.,
ALLOY CULVERT PIPE, MINIMUM COVER 24
INCHES FROM INLET TO TOP OF SLOPE AT
SECOND TRENCH. TAIL SECTION OF CULVERT
AT DOWNSTREAM END, LOCATION TO BE
DETERMINED IN FIELD BY THE ENGINEER.

PHASE II:
INSTALL INLET (SEE DETAILS ON
CROSS SECTIONS, SHEET #)
PROPERTY LINE STA. 11+00 AT 10' RT.
TRANSITION BUTTER TO MEET INLET OPENING.

- PHASE I CONSTRUCTION CONSISTS OF THE FOLLOWING:
- CONSTRUCTION OF HEADER AND LATENT TRENCHES AS SHOWN ON THE PLANS.
 - EXCAVATING AND PLACING CONTROLLED FILL IN AREA OF TENSION CRACKS.
 - DRESSING AND RE-SHAPING SLOPE AND ROAD AFTER COMPLETION OF 11 AND 21.
 - SEEDING, LINING AND FERTILIZING, AND MULCHING, OF ALL DISTURBED AREAS, EXCEPT ROADWAY.
 - REPLACING ROAD SURFACE IN AREA OF TENSION CRACK.
- PHASE I SHALL BE COMPLETED WITHIN 20 WORKING DAYS.

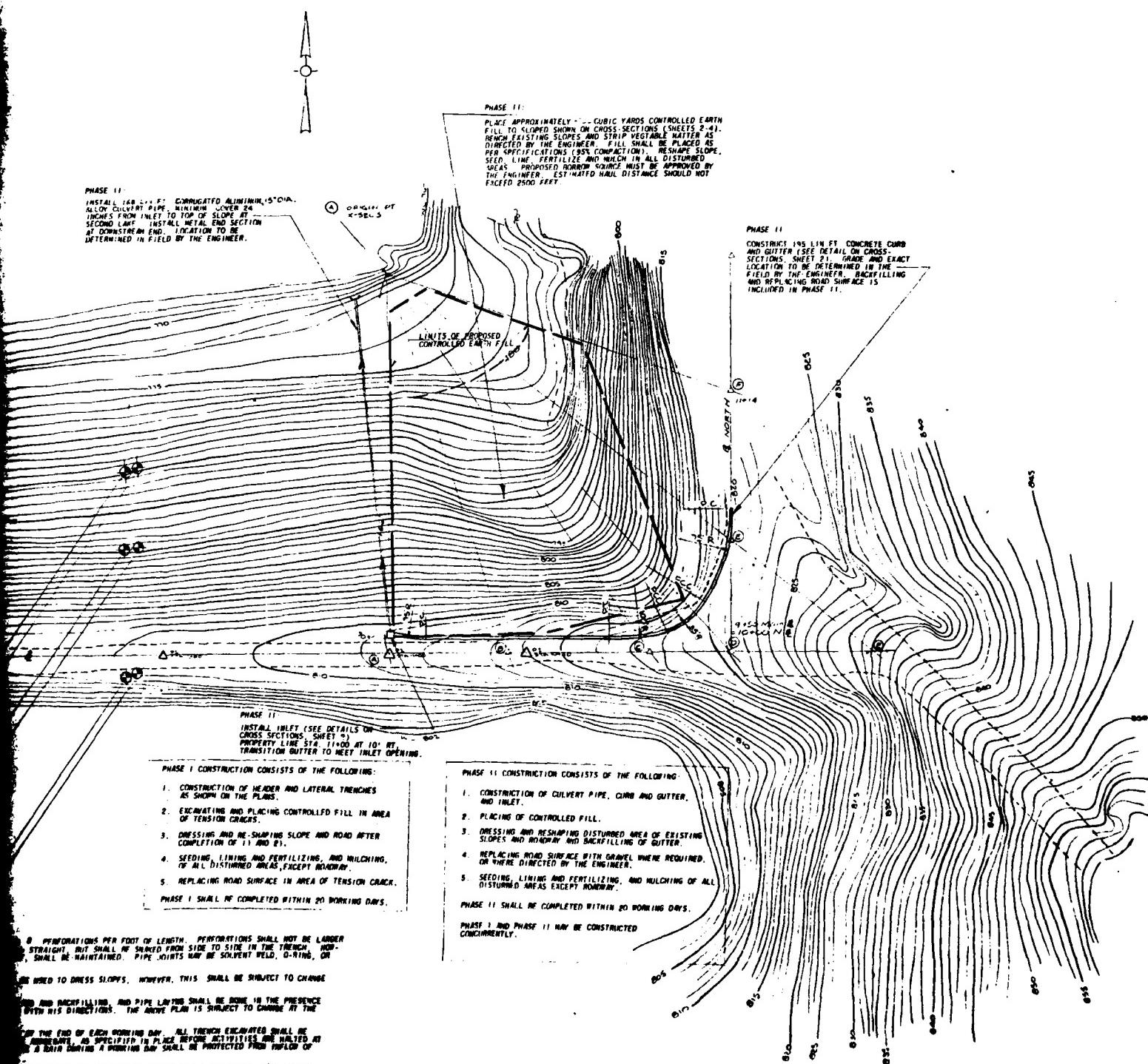
- NOTES:
- PERFORATED PLASTIC PIPE SHALL HAVE NO LESS THAN 8 PERFORATIONS PER FOOT OF LENGTH. PERFORATIONS SHALL NOT BE LARGER THAN 1/8" DIAMETER EACH. PIPE SHALL NOT BE LAIN STRAIGHT, BUT SHALL BE BENDED FROM SIDE TO SIDE IN THE TRENCH. HOWEVER, MINIMUM SIDEWALL CLEARANCE AS SHOWN ABOVE, SHALL BE MAINTAINED. PIPE JOINTS MAY BE SOLVENT WELD, O-RING, OR OTHER TYPE APPROVED BY THE ENGINEER.
 - IT IS PROPOSED THAT SURPLUS EXCAVATED MATERIAL BE USED TO DRESS SLOPES. HOWEVER, THIS SHALL BE SUBJECT TO CHANGE AT THE OPTION OF THE ENGINEER.
 - ALL ACTIVITIES PERTAINING TO DRESSING, COMPACTING AND BACKFILLING, AND PIPE LAYERS SHALL BE DONE IN THE PRESENCE OF THE CONTRACTOR AND SHALL BE DOWNGED IN ACCORDANCE WITH HIS DIRECTORS. THE DRIVE PLAN IS SUBJECT TO CHANGE AT THE DISCRETION OF THE ENGINEER.
 - NO MORE THAN 8 FEET OF TRENCH SHALL REMAIN OPEN AT THE END OF EACH WORKING DAY. ALL TRENCH EXCAVATED SHALL BE BACKFILLED WITH PIPE, COARSE AGGREGATE, OR FINE AGGREGATE, AS SPECIFIED IN PLACE BEFORE ACTIVITIES ARE HALTED AT THE END OF THE WORKING DAY. TRENCH OPENED BEFORE A RAIN DURING A WORKING DAY SHALL BE PROTECTED FROM RIFLEOF OF SURFACE WATER IF IT CANNOT BE BACKFILLED.
 - THE CONTRACTOR SHALL REMOVE POSTS AND CABLE ROAD GUARD RAILS WHEN THEY MAY INTERFERE WITH CONSTRUCTION. REPLACEMENT IS NOT NECESSARY.
 - SHADED AREAS INDICATE ROCK OR SURFACE UNLESS OTHERWISE NOTED.

- PHASE II
1. CONSTRUCTION
2. PLACEMENT
3. DRESSING
4. REPLACEMENT
5. STEPPING
DISTANCE

PHASE II
CLOSING

TE

NOTES: CONTOUR INTERVAL IS ONE FOOT.
BM ELEV. 602.0 IS EL OF 2ND
PIPE FROM WEST END OF
SPILLWAY.



APPENDIX B 3

**ATE
LME**